"WISE INVESTMENTS": A Yearlong Pilot Program Introducing Engineering to Teachers and Counselors

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Abstract

A recent, successful project within the Women in Applied Sciences and Engineering (WISE) Program at Arizona State University, WISE Investments, was designed to teach middle and high school math and science teachers to integrate engineering concepts and applications into their curricula. Integrating engineering into math and science curriculum provides relevance and context for what the students are learning, encourages students to continue their math and science studies, and motivates students to consider engineering and related careers. Furthermore, by presenting engineering as a helping profession, these applications may particularly appeal to females and minorities. Unfortunately, many math and science teachers are unaware of how engineers use math and science to solve problems.

WISE Investments was also designed in order to teach middle and high school guidance counselors how to enhance their efforts to support and to encourage underrepresented students to pursue engineering and related careers. Including guidance counselors helps to create a support network for underrepresented students' pursuit of engineering and related fields. These interventions will ultimately increase the number of women and minorities pursuing degrees in engineering and related fields.

As a kick-off to the yearlong program, WISE Investments brought 24 middle and high school math and science teachers, from 11 schools, and six district-level administrators, from five participating school districts, to ASU for a two-week intensive summer workshop in engineering. For the first week of the workshop, a counselor from each of the 11 schools also joined each team, but participated in a somewhat specialized workshop.

On-campus labs focussed on different areas of engineering with a unifying theme of "Engineering as a Helping Profession." They included hands-on activities that could be replicated or easily modified for use in a middle school or high school classroom. Teachers participated in two industry tours and heard a number of presentations by lunchtime keynote speakers from engineering-related industries. A two-week internship with one of the industry partners was included in the WISE Investments program as part of the year-long activities for the participants.

Introduction

Research suggests that a crucial intervention point for encouraging students to pursue math- and science-related fields is during middle school. There is an overall decline in both male andfemale students' liking and enjoyment of math from sixth to twelfth grade [1]. Students report that math becomes more difficult, that they receive less support from parents, teachers and peers for studying math, and that math becomes more anxiety provoking over time. Female students reported that math was more difficult than did male students, and females rated themselves as more anxious in quantitative situations than males, even though their mathematical ability was approximately equal [2]. In fact, as early as the seventh grade, boys plan to study more math than girls do [3]. High school girls perceive math to be less useful than boys do [4], and value math less than boys do [5]. Research supports the idea that the factors that keep minorities from entering these fields are largely the same as those responsible for the underrepresentation of women [6].

In addition, many math and science teachers are unfortunately unaware of how engineers use math and science to solve problems. Also, studies of science and math classrooms have found that teachers interact differently with males and females, resulting in more contact and more critical feedback for male students [7]. A recent study found that teachers are concerned about gender inequity, but are not familiar with the possible causes, nor are they aware of the effectiveness of interventions [8]. In fact, many teachers feel that attempting such interventions is a form of reverse discrimination [9].

The Women in Applied Sciences and Engineering (WISE) Program was established at Arziona State University (ASU) in 1993 to recruit and to retain more women into engineering and construction. In order to recruit more young women, WISE determined that partnerships and working relationships with local science and math teachers, as well as counselors, were needed. A "WISE Investments" Program was designed to: Provide teachers with a hands-on introduction to a variety of engineering fields; Teach them the engineer problem-solving approach; Enable them to create gender and culture-inclusive engineering applications for the math and science classes they currently teach; Give them a working knowledge of what engineers do in various settings; and provide them with an understanding of what skill sets an engineer, or student pursuing an engineering major, needs. By infusing engineering problem-solving concepts and applications into math and science curricula, students are provided with a context for the material they are learning. Furthermore, demonstrating that engineers use math and science to solve real-world problems and to help people is designed to be particularly appealing to female students who are socialized to enter nurturing and people-oriented careers. For example, one study found that young women planning careers in science were drawn to them because of a desire to help [10].

Program Description

WISE Investments brought 24 middle and high school math and science teachers from 11 schools and six district-level administrators from five participating school districts to the ASU campus for a two-week intensive summer engineering workshop in1998. For the first week of the program, a counselor from each of the 11 schools also joined each school's team. By including the counselors in this training, they had significant interactions with the teacher participants, facilitating a collaborative partnership on their home campuses.

During the workshops, the teacher participants were exposed to eight fields of engineering (Biomedical, Chemical, Civil/Environmental, Computer Science/Systems, Electrical, Industrial, Materials, and Mechanical/Aerospace) through eight hands-on labs conducted by ASU engineering faculty. Engineering career information was also supplied through two workplace industry tours and a series of lunch-time keynote speakers from engineering-related industry. The counselors participated in the orientation, two hands-on engineering labs, one workforce industry tour, the gender and culture-equity training, and the Internet workshop with their school teams. Additionally, the counselors moved into their own sessions to receive intensive training about how to advise underrepresented students who are talented in math and science, and how to design and to implement outreach programs about math, science and engineering fields for underrepresented students on their own campuses. In addition to the workshop, counselors attended the last-day's luncheon that concluded the two-week teacher's workshop.

For the teachers, engineering content was learned through the hands-on activities that were connected to careers both through information specific to each discipline presented within each lab and through industry tours and lunch-time keynote speakers. These speakers were underrepresented engineers or other company representatives who could speak to the job description and career path for engineers in their work environment. Tours allowed participants to view, first-hand, the settings in which some engineers work, the equipment they work with, and the number of engineering positions available in a variety of industries.

After completing the series of engineering labs, participant teams selected an area of engineering within which to develop an application. Engineering faculty served as mentors during this development process. During the last two days of the program, each team of teachers presented their engineering application to the other teams. During the workshop, teacher participants also received training on establishing a gender- and culture-inclusive classroom. In addition, participants received training on e-mail and the internet and explored resources relevant to engineering and education available on the World Wide Web.

For their participation in the two-week training, teacher participants received either a stipend or district credit (as stipulated by district policy) and, if desired, graduate credit at ASU. For their participation in the workshop, counselor participants also received a stipend or district credit and graduate credit, if desired.

During the academic year following the training, teachers participated in three, half-day follow-up sessions. Two of these sessions took place at ASU and included a focus group to determine participants' perceptions of the program, training on assessment relative to the engineering applications, and opportunities to problem-solve or develop further engineering applications. These sessions were held during school hours and teachers had release time to attend them. A mentor team, consisting of an engineer from a participating industry partner, an engineering faculty or staff member, and an underrepresented engineering student was formed for each school. Prior to serving in the schools, this mentor team attended a workshop to prepare for this experience. The workshop included engineering activities to use during their presentations and training on how to make their presentations gender-inclusive, age appropriate, and a positive learning experience. During the spring, 1999, mentor teams visited and guest-taught in the teacher's classroom twice.

In addition to the follow-up sessions, each teacher committed to the following academic year activities: 1) Provide a written description of their engineering applications to be disseminated through the project's materials and World Wide Web home page; 2) Report on their involvement and activities in one of three ways: a workshop for teachers in their district, a presentation to faculty on their own campus, or participation at a district curriculum writing activity; 3) Participate in an electronic forum; 4) Participate in the one-day workshop; and 5) Participate in the assessment process of their students pre and post implementation of the engineering application.

In addition to their workshop and internship, counselor participants are required to: 1) Write a description of their outreach program to be disseminated through the project's World Wide Web home page; 2) Implement their outreach program on their campus; 3) Attend at least one of the engineer mentor team's presentations on their campus; 4) Attend two of the follow-up sessions; and 5) Participate in the electronic forum. For their participation in academic-year activities, teacher and counselor participants receive an additional stipend or district and graduate credit, if desired. Counselor participants are also invited to attend the end of the year forum.

Engineering Internship

Each of the participants had the opportunity to complete a two-week internship with one of the project's industry partners. The internships allowed teachers and counselors an opportunity to understand the role of an engineer in various settings on a day-to-day basis. Participants took an active part in engineering-related activities, gaining hands-on experience in a real-world setting. For their participation in this portion of the program, participants received a $500 stipend.

End of Year Forum

In order for participants to learn about the various applications developed and implemented throughout the year, a poster-session type exchange will take place this May, 1999 at the end of the year forum. Each team will create a display explaining their efforts to date. From this exchange, one team will be selected to receive sponsorship from the program to travel to a regional or national education conference to report on the program and their engineering applications. To celebrate each participant's achievements, the forum will culminate in a banquet for participants, their principals, district representatives, and advisory committee members. At this time, participants that satisfactorily achieved the program's goals, will receive a certificate of program completion.

Collaboration

WISE Investments is a joint venture of ASU's College of Engineering and Applied Sciences (CEAS), College of Education (COE), Phoenix Union High School District, Tempe Union High School District, Chandler Unified School District, Kyrene School District, Roosevelt School District, The Institute for Future Workforce Development, Intel Corporation, Motorola, Andersen Consulting, Lockheed Martin Corporation, Salt River Project, Honeywell, and Boeing. Partial funding for this pilot project was provided by an Eisenhower Grant.

Evaluation

Evaluations of each summer lab were completed immediately by participants to provide feedback about the effectiveness of the lab. The following is a sample of some of the participant comments:

> *"Dr. Houston's discussion of women in engineering was very enlightening. She also had students demonstrate activities. One activity was also designed with handouts to be performed with us. Had fun!"*
>
> --High School Counselor

> *"The Aerospace was an awesome lab! Those four hours flew by! I use rockets in my class and this just helped to increase my knowledge of the subject!"*
>
> --Middle School Teacher

> *"In terms of the industrial engineering lab: WOW! My jaw was constantly on the floor. Is it too late for me to become an industrial engineering student? It was such an eye opener for me."*
>
> --High School Teacher

Although it is yet too early for the teachers to administer their student post-tests, a sample of the outcomes to be assessed and their method include the following:

- **Outcome**: An integration of engineering information and activities into teacher participants' classrooms.
- **Assessment**: Teacher portfolio of project, including written description of how information and activities were integrated and presented.

- **Outcome**: An increased interest in engineering and related fields by participants' students.
- **Assessment**: 1.) Pre and post assessment of students' interest in math and science using a modified version of the Math/Science Interest Inventory [11]. Pre and post group means would be compared using a paired t test. 2.) Pre and post assessment of the participants' students' interest in careers utilizing a modified version of the Careers Interest Scale [12]. This scale has been modified to yield three scores: Engineering, science and nonscience (as opposed to science and nonscience only). Pre and post group means for the three scales would be compared using a paired t test.

- **Outcome**: An increase in plans to pursue engineering and related fields by participants' students.
- **Assessment**: Pre and post assessment of students' desired career. Careers would be classified into Engineering, Science and Nonscience careers. Pre and post group means for the three areas (engineering, science, nonscience) would be compared using a paired t test.

Conclusion

This pilot program was judged successful. Funding from the National Science Foundation has now been received to expand the program and to continue it for an additional three years. This "new" program will be based heavily on our experiences with the WISE Investments pilot project.

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